DISPERSION COMPENSATION IN 40 Gb/S WDM NETWORK USING DISPERSION COMPENSATING FIBER

[1] MR. GAURANG.H.PATEL, [2] PROF. ROHIT.B. PATEL, [3] PROF. SWETA.J.PATEL

[1]M.TECH. [Electronics & Communication Eng.] Student, Department Of Electronics and CommunicationEngineering, U.V.Patel College of Engineering, Ganpat University, Gujarat
[2] Associate Professor, Department Of Electronics and Communication Engineering, U.V.Patel College of Engineering, Ganpat University, Gujarat
[3] Assistant Professor, Department Of Electronics and Communication Engineering, U.V.Patel College of Engineering, Ganpat University, Gujarat

gauranglang@gmail.com,rohit.patel@ganpatuniversity.ac.in,er.swetapatel@gmail.com

ABSTRACT : *Optical Fiber cable offers very high bandwidth. For making the efficient utilization of available bandwidth many signals should be transmitted through the same cable. WDM Network allows several channels to be routed through the same fiber cable on different Wavelength. Dispersion is the major limiting factor in High speed optical WDM Network. Dispersion causes pulse broadening and pulse distortion. In this paper, Analysis of WDM Network has been done with Non-Return to Zero modulation formats. The system has been analysed using pre, post and mix dispersion compensation schemes. We have simulated 40 GB/s WDM Network supporting four users. All these three schemes are compared in terms of Q-factor and Bit Error Rate. The mix compensation scheme is superior than pre and post compensation scheme means it provide high Q-Factor and Minimum BER.*

KEYWORDS: Dispersion, WDM, Dispersion Compensating Fiber, Q-Factor and BER.

1. INTRODUCTION

WDM optical network has bring the performance improvement in data transmission because of high speed, high bandwidth and high capacity. So a lot of research is going on in this field. In WDM networks optical fibers are used to transmit information between the transmitter and the receiver. WDM systems have the capability to transmit multiple signals simultaneously. In WDM Network, different signals from different users are multiplexed. But the light signals degrade in intensity when they travel inside the fiber. Fibers suffer from dispersion other nonlinearities due to fiber material nonlinearities and distance the signal travels inside the fiber. In WDM network, dispersion, Group velocity dispersion (GVD) and nonlinear effects, like self phase modulation, cross phase modulation and four-wave mixing is observed at different data rates. So this dispersion and fiber nonlinearities at different data rate must to be minimised by different dispersion compensation techniques like dispersion compensation fiber, fiber Bragg grating, optical phase conjugation and electrical compensation methods.

2. NEED FOR DISPERSION COMPENSATION

In optical Fiber Communication, when light signal is propagated through the fiber, due to the dispersion system performance is degraded. In dispersion, different modes travel with different group velocity due to the material and waveguide property of the fiber. So ultimately all the modes reached at the different times results in pulse broadening means inter symbol interference occur. The classification of different types of dispersion is shown in figure below.

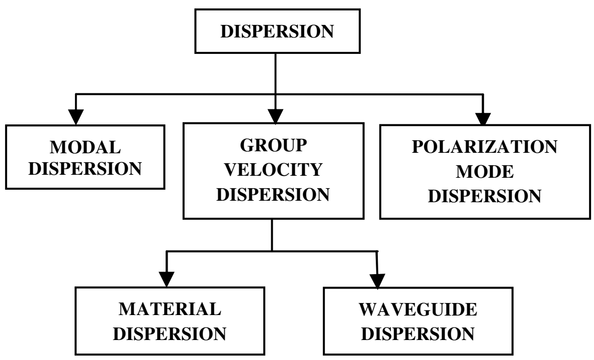


Fig 1. Classification of Dispersion

Material dispersion is caused by due to the material property of the fiber. Material dispersion is due to the change in refractive index of material with wavelength. Waveguide dispersion is due to the physical structure of fiber means because of the refractive index profile of the core and cladding of the fiber. Modal dispersion is generally observed in multimode fiber due to the multiple mode travel with different group velocity. Polarization mode dispersion is caused by different polarization state of pulse travel with different velocity results in pulse broadening.

To avoid the broadening of the pulse dispersion should be compensated in optical network. There are different techniques possible for dispersion compensation like use of dispersion compensating fiber, use of fiber Bragg grating, use of optical phase conjugation and use of electronic equalizers. Among these, dispersion compensating fiber is efficient way of reducing dispersion in optical fiber communication system.

In this paper, to compensate for Dispersion Dispersion Compensating Fiber Technology is used. Three different schemes i.e. Pre compensation, Post compensation and Mix Compensation are simulated.

3. DISPERSION COMPENSATING FIBER

Dispersion compensating fiber is an easy and efficient way to upgrade installed links made of single mode fiber. Dispersion compensating fibers have negative dispersion of -70 to -90 ps/nm.km and can be used to compensate the positive dispersion of transmission fiber. Performance degradation in optical WDM system is because of group velocity dispersion, Kerr nonlinearity, and accumulation of amplified spontaneous emission noise due to periodic amplification. Because of the nonlinear nature of propagation, system performance depends on the power levels at the input of different types of fibers, on the position of the DCF and on the amount of dispersion . There are basically three pre, post and symmetrical compensation schemes where the DCF is placed before, after the SMF or symmetrically across the SMF. A DCF should have low insertion loss, low polarization mode dispersion and low optical nonlinearity and also it should have large chromatic dispersion coefficient to minimize the size of a DCF. Smaller size of the DCF is preferable. By placing one DCF with negative dispersion after a SMF with positive dispersion, the net dispersion should be zero.

$$D_{SMF} \times L_{SMF} = -D_{DCF} \times L_{DCF}$$

Where *D* and *L* are the dispersion and length of each fiber respectively.

Compensation is done by three different methods depending on the position of the DCF:

(i) Pre-Compensation
(ii) Post Compensation
(iii) Mix Compensation

Pre-Compensation: In this Compensation scheme, the dispersion compensating fiber of negative dispersion is placed before the standard fiber to compensate positive dispersion of the standard fiber.

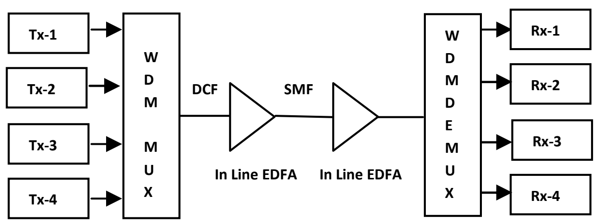
Post-Compensation: In this Compensation scheme, the dispersion compensating fiber of negative dispersion is placed after the standard fiber to compensate positive dispersion of the standard fiber.

Mix-Compensation: In this Compensation scheme, the dispersion compensating fiber of negative dispersion is placed before and after the standard fiber to compensate positive dispersion of the standard fiber.

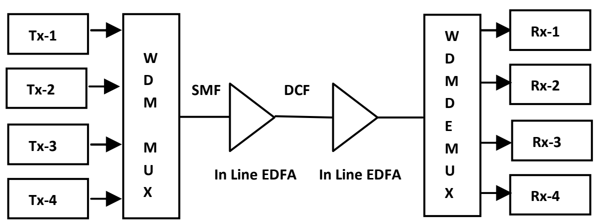
4. SIMULATION SET-UP

To achieve high-capacity, high speed wavelength-division-multiplexing (WDM) transmission, the embedded standard single-mode fiber (SMF) should be upgraded to compensate the dispersion. For this purpose, some dispersion compensation scheme must be used periodically in the link. There are several different methods that can be used to compensate for dispersion, including dispersion compensating fiber (DCF),fiber Bragg gratings, optical phase conjugation and electrical dispersion compensation. we have simulated one Wavelength division multiplexing topology supporting four user and operated at data rate of 4×10 Gb/s=40 Gbps. In this topology, to compensate dispersion, dispersion compensation fiber (DCF) technology is used. We have simulated three DCF compensation scheme, pre-compensation, post compensation and mix compensation scheme at 40 GB/s. Among these entire three schemes Mix compensation scheme can greatly reduce the dispersion effects, this program is better than the pre compensation and post compensation program. The above techniques are compared in terms of Q-factor and Bit error rate.

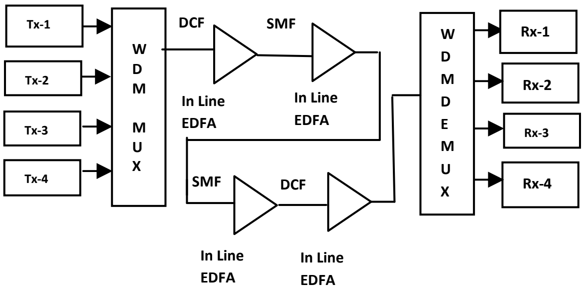
Fig.2 shows Block diagram of simulation setup of a 4 channel WDM optical communication system at 40 GB/s. The simulation parameters and fiber parameters used in the system model are given in Table 1. The simulation setup is composed of transmitter, fiber and receiver. The WDM transmitter consists of a CW laser source for each channel, data modulators and the optical multiplexer. To the output port of the CW laser a data modulator has been connected. Optical signals from 4 data modulators are fed to the 4 input ports of an optical multiplexer.



(a)



(b)



(c)

Fig 2. Block Diagram of Simulation Setup: (a) Pre compensation scheme (b) Post compensation scheme (c) Mix compensation scheme

The transmission link span at 40 GB/s is designed suitably by considering the fiber parameters of DCF and SMF so that the dispersion is compensated exactly. The gain of the erbium doped fiber amplifier (EDFA) placed after each fiber is such that is compensates the losses of the preceding fiber. The noise figure of the amplifiers is constant and set to 4 dB.The signal is then launched over N spans of standard single mode fiber (SMF) of 60 km each.WDM system has been simulated for three different dispersion compensation schemes i.e. pre-compensation, post-compensation and mix-compensation. In pre-compensation scheme, as shown in Fig 2(a), to compensate for the dispersion, DCF fiber of 12 km is used prior to the SSMF fiber of 60km length. Also, two in-line-EDFA with gain of 6 and 10 dB have been used in the link. The post-compensation scheme has been shown in Fig 2(b) where DCF fiber of 10km is used after the SMF fiber of 50km length to compensate the accumulated dispersion. In mix- compensation scheme, as shown in Fig 2(c), two DCF fibers of 6 km are used before and after of the two SMF fibers of 30 km length each. Here four in-line-EDFA have been used in the link. In the receiver the signal is demultiplexed, detected by PIN detector, passed through the filter. The filtered electrical signal connected directly to the BER analyser which is used as a visualize to generate graphs and results such as eye diagram, BER, Q value, eye opening etc. The parameters used in simulation are given in Table 1.

Parameter	Value
Bit-Rate	40 Gbps
Length of SMF	120 Km
Length of DCF	24 Km
Dispersion coefficient of SMF	16 ps/nm/km
Dispersion coefficient of DCF	-80 ps/nm/km
Gain of Inline EDFA	14.4 db
Gain of Inline EDFA	24 db
Attenuation factor of SMF	0.2 db/km
Attenuation factor of DCF	0.6 db/km

Table 1. Parameters used in simulation

5. SIMULATION RESULTS

The three different dispersion compensation schemes i.e., pre-compensation, post-compensation and mix-compensation have been analysed for 40 GB/s WDM system in terms of received maximum Q value and Minimum Bit error rate. To analyse the system, the results of the first channel have been taken. The Eye diagram of the pre-compensation is shown in figure below.

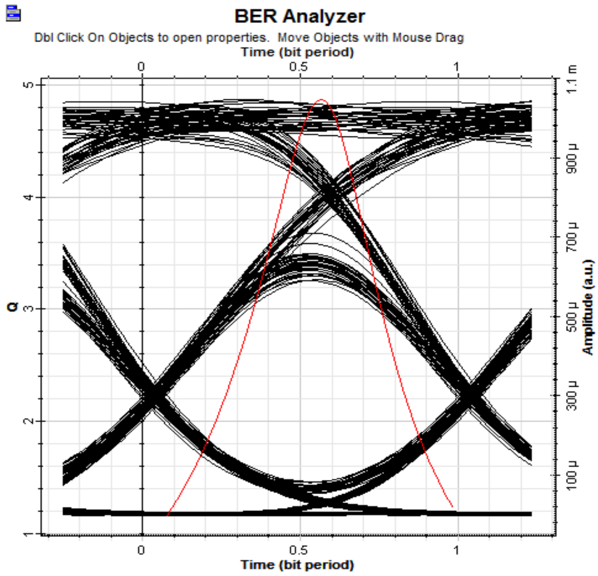


Fig 3. Eye Diagram of pre-compensation scheme.

As shown in above figure pre-compensation provide Q-factor of 4.8720 and BER of 4.08×10^-7.

The Eye diagram of the post-compensation is shown in figure below. As shown in figure post-compensation provide Q-factor of 4.9843 and BER of 2.32×10^-7.

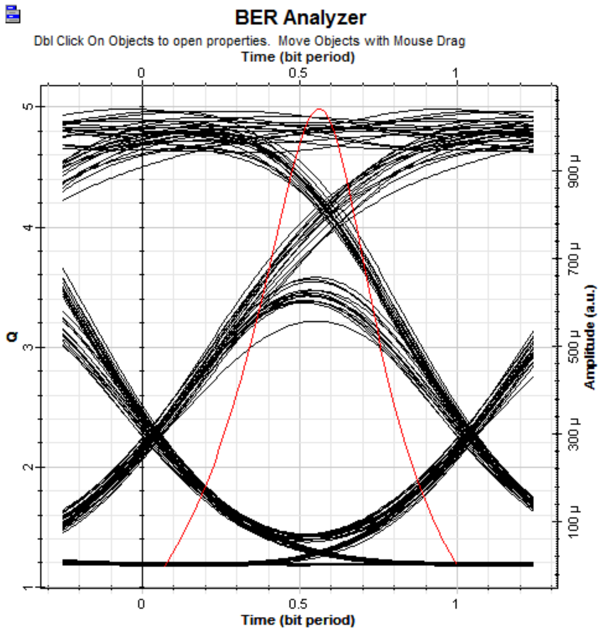


Fig 4. Eye Diagram of post-compensation scheme.

The Eye diagram of the mix-compensation is shown in figure below. As shown in figure mix-compensation provide Q-factor of 5.0224 and BER of 1.91×10^-7.

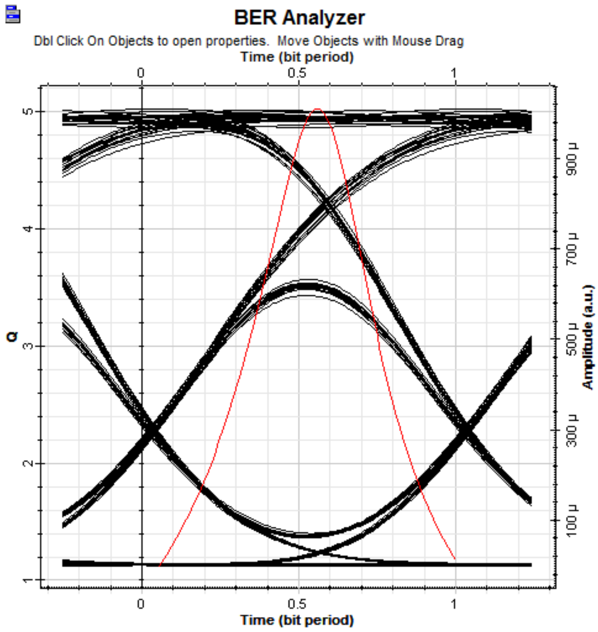


Fig 5. Eye Diagram of mix-compensation scheme.

The Comparison of above compensation schemes in terms of Q-Factor and BER is given in Table 2.

Scheme	Q-Factor	Bit Error Rate
Pre Compensation	4.8720	4.08× 10^-7
Post Compensation	4.9843	2.32× 10^-7
Mix Compensation	5.0224	1.91× 10^-7

Table 2. Comparison of Dispersion Compensation Schemes

6. CONCLUSION

In this paper, we have simulated one 40 GB/s WDM Network. To compensate dispersion, we have used Dispersion compensating fiber. Three different compensation schemes Pre, post and mix compensation are simulated. These schemes are compared in terms of Q-Factor and BER. After simulation we have conclude that mix compensation is the best dispersion compensation scheme than pre and post compensation.

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